

# design ideas

Edited by Bill Travis and Anne Watson Swager

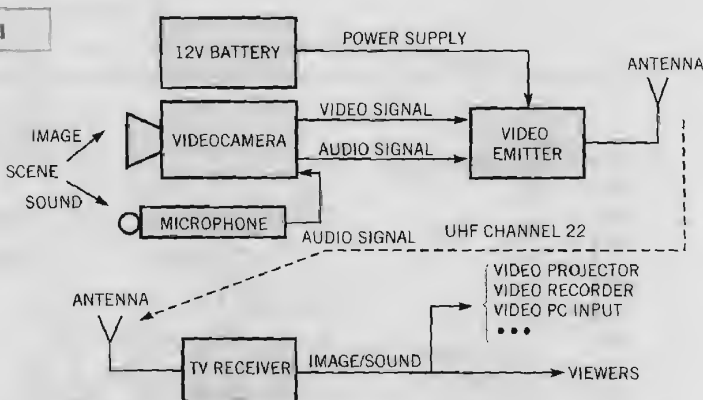
## Video emitter uses battery power

JM Terrade, Clermont-Ferrand, France

**T**HE BLOCK DIAGRAM in Figure 1 shows how to make a cable-free, direct-video system. The

system allows users to walk from booth to booth at an exhibition to interview people and to display the interviews in real time on three screens at key locations. You can use the small and simple system each time you need to capture image and sound on the run. Figure 2 (pg 96) shows a detailed schematic diagram of the video system. The system provides no stereo audio but rather mixes together right and left sources. IC<sub>2A</sub> acts as an inverter/adder. At Point C, the ac signal represents the sum of the left and right channels:  $V_C = -R_1(V_A/R_2 + V_B/R_3)$ . With the same value for the three resistors,  $V_C = (V_A + V_B)$ . C<sub>8</sub> and C<sub>9</sub> block any dc voltage at points A and B. IC<sub>2A</sub> works from a single 12V supply but needs a continuous bias voltage to provide a positive and negative swing around 6V. R<sub>4</sub> and R<sub>5</sub> create a 6V bias source for both IC<sub>2A</sub> and IC<sub>2B</sub>. IC<sub>2B</sub> acts as an inverting voltage amplifier with a gain of  $P_1/R_8$ . With the values shown, you can adjust the gain as high as 4.7. You can adjust P<sub>1</sub> for audio gain as high as 13 dB. C<sub>10</sub> blocks the 6V dc at Point D, so only the ac audio voltage is present at the audio input of IC<sub>4</sub>. The LM358N works well from a single

Figure 1



A wireless, battery-powered video system uses UHF Channel 22 to transmit signals to video receivers.

supply, but when the output voltage is close to 0V, it needs some help to avoid signal distortion. Pulldown resistors R<sub>6</sub> and R<sub>7</sub> minimize the distortion.

IC<sub>4</sub> is a video-emitter IC from Aurel ([www.aurel.it](http://www.aurel.it)) that works in the UHF band at 479.5 MHz (UHF Channel 22). Its output power is 2 mW to a 75Ω antenna, A<sub>2</sub>. Typical supply current is 90 mA. The signal from the videocamera connects directly to IC<sub>4</sub>'s input. If you need more power, you can add IC<sub>3</sub>, also from Aurel. This IC works in the same frequency band as IC<sub>4</sub> and boosts power to 19 dBm in the 75Ω antenna. Both IC<sub>3</sub> and IC<sub>4</sub> are available in small, single-inline packages. A Switching Level signal from Pin 8 of the SCART video connector is present when the videocamera is on. The current consumption of IC<sub>3</sub> and IC<sub>4</sub> is 90 (5V) and 100 mA (12V), respectively. To reduce power consumption, a dual-contact relay, K<sub>1</sub>, connects IC<sub>3</sub> and IC<sub>4</sub> to the supplies only when the

camera is on. When the videocamera is off or disconnected, the supply current decreases to only a few milliamperes.

IC<sub>5</sub> and C<sub>4</sub> through C<sub>7</sub> provide a 5V supply to IC<sub>4</sub>. IC<sub>1</sub> and C<sub>1</sub> through C<sub>3</sub> provide a stable 12V supply to IC<sub>3</sub> and the LM358. You can connect a 12V battery directly to J<sub>1</sub>. IC<sub>3</sub>'s data sheet specifies a supply level of 11.4 to 12.6V, but tests show that the IC works properly if the supply is higher than 11V. The total 200-mA current consumption yields approximately three-hour battery life with 12 AA cells. If you use a switching power supply, you would obtain longer battery life, but you need to take filtering measures to avoid interference with the video path. If an ac outlet is available, you could use an 18V, 300-mA wall adapter to replace the battery.

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Video emitter uses battery power.....	95
Circuit avoids metastability.....	96
Microphone uses "phantom power" .....	100
Measure humidity and temperature on one TTL line.....	102
Low-cost anemometer fights dust .....	102



When the two clocks are nearly in phase, the duty cycle of  $IC_{1A}$ 's output is close to 0%. When the two clocks are close to  $180^\circ$  out of phase, the duty cycle approaches 100%. Whatever the duty cycle is, it is constant during normal operation. The only way it can change is for the cable length between the two systems to change.  $R_1$  and  $C_1$  form a lowpass filter. Set  $R_3$  equal to  $R_4$  so that the reference voltage is at midpoint.  $IC_2$  and  $IC_{1B}$  then select whether to clock register  $IC_3$  on the rising or falling edge of the host clock.  $IC_4$  ensures that the data changes consistently with the rest of the host system. **Figure 3** shows a (delayed) remote clock that is nearly  $360^\circ$  out of phase with the host

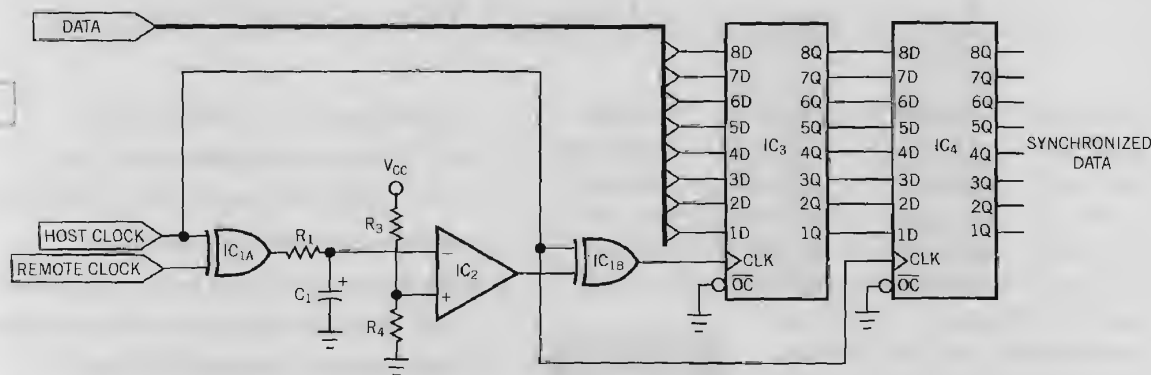
clock. If the host were to clock in the data on the rising edge of its clock, metastability would become a concern. You can simply clock in the data on the falling edge of the host clock, but this solution yields the same problem if you choose a new cable with a different length.

Without any analytical effort on the designer's part, the circuit in **Figure 2** automatically selects which clock edge to use. Note that comparator  $IC_2$  can be a low-speed part, because it operates at dc only. Note also that if the two clocks are  $360 \pm 90^\circ$  out of phase, the circuit uses the falling edge of the clock. If they are  $180 \pm 90^\circ$  out of phase, the circuit uses the rising edge. If the  $R_1 C_1$  time constant is

too low, the resulting ripple can cause the output of the comparator to be unstable. You could use a comparator with hysteresis to reject the ripple. Some instability of the comparator's output is acceptable, because you can safely use either the rising or the falling edge for most latencies. You need stability only when the clock is near  $360$  and  $180^\circ$  out of phase, so you have little to lose by using a large  $R_1 C_1$  time constant to present a dc voltage to the comparator's input.

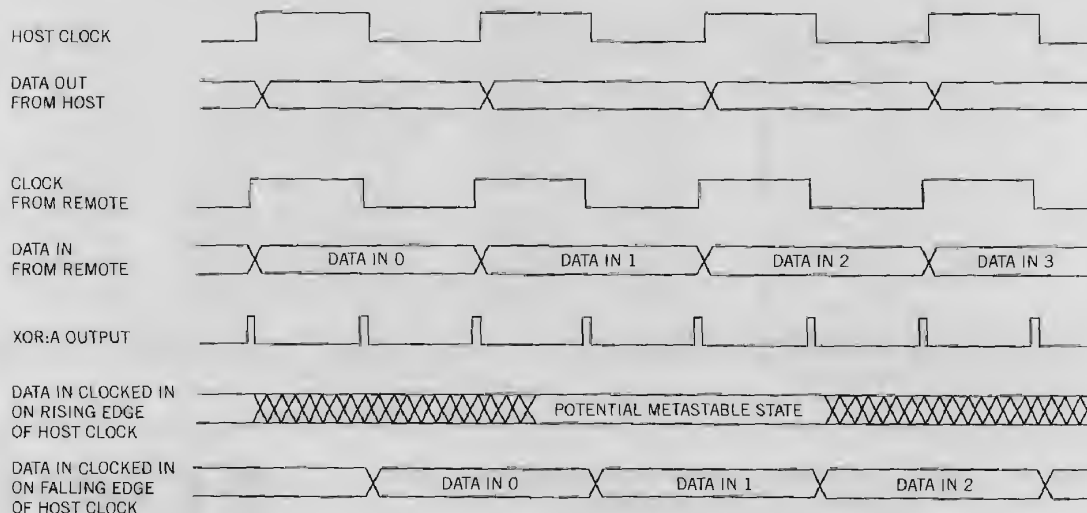
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**Figure 2**



This circuit automatically chooses between the rising and the falling edge on the host clock for clocking in data.

**Figure 3**



Clocking data on the wrong edge can result in metastability; the circuit in **Figure 2** selects the right edge.

# Microphone uses "phantom power"

Bruce Trump, Texas Instruments, Tucson, AZ

THE ELECTRET MICROPHONE capsule is similar to those commonly used in telephones, cassette recorders, and computers. The element functions as a capacitor with a fixed trapped charge. Sound pressure moves a diaphragm, producing variations in the capacitance. This action produces an ac-output voltage with an extremely high source impedance. A FET inside the capsule uses an external-resistor drain load (Figure 1).  $R_1$  and  $R_2$  provide an appropriate load impedance and voltage from the 10V supply. The basic performance of this simple capsule is excellent, but it requires further signal processing to conform to professional phantom-powered-microphone standards.

The output of a phantom-powered microphone is a low-impedance differential signal.  $IC_1$  is a simple voltage buffer that provides low-impedance drive for one output.  $IC_2$  is a unity-gain inverter that derives its drive from the output of  $IC_1$ . Bias for the noninverting input of  $IC_2$  comes from a heavily filtered output of  $IC_1$ . We selected the dual op-amp  $IC_1/IC_2$  for its low noise and low distortion properties.  $R_6$  and  $R_7$  provide immunity from long-line capacitance, RF interference, and transients that occur when you "hot-plug" the microphone into a live phan-

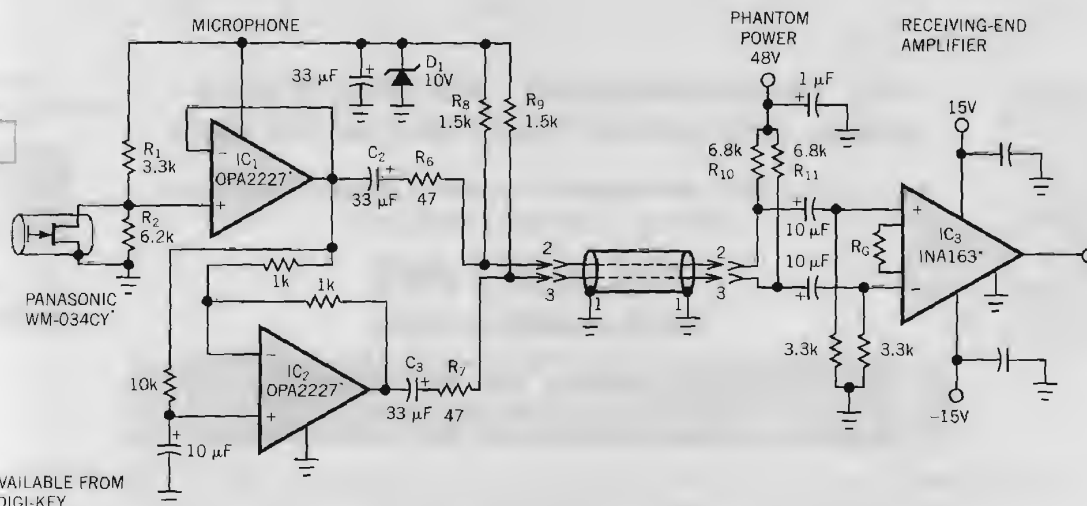
tom-power source. The amplifier outputs use ac coupling,  $C_2$  and  $C_3$ , to the microphone's output terminals to block the dc phantom-power voltage on the audio lines. Differential-output voltage capability is limited to approximately 2V p-p because of the limited power supply available to drive the op-amp output currents. This level is adequate, because it corresponds to an extraordinary sound level beyond the linear range of the capsule.

Phantom-powered microphones derive power for their active circuitry from the receiving-end circuit through the same leads that transmit the audio signal. The 48V phantom-power supply couples through two 6.8-k $\Omega$  resistors,  $R_{10}$  and  $R_{11}$ , to both signal lines. This coupling allows the microphone's low output impedance to drive a differential ac signal on the relatively "soft" impedance of the phantom supply voltage. In the microphone, power comes from the signal lines through resistors  $R_8$  and  $R_9$ . Zener diode  $D_1$  regulates the voltage. These resistors also provide a soft impedance on the balanced line, allowing the outputs of  $IC_1$  and  $IC_2$  to inject their differential ac-output signal. You can locate the microphone hundreds of feet from the receiving-end phantom power and amplifier and still obtain excellent performance.

The receiving-end amplifier,  $IC_3$ , is a low-noise instrumentation amplifier with three internal op amps. Its configuration and laser-trimmed resistors provide excellent CMR (common-mode-rejection) properties. The high CMR rejects noise and power-line hum that appear equally in both signal lines. Low noise (1 nV/ $\sqrt{\text{Hz}}$ ), though unnecessary for high-output microphones such as those described here, is necessary in professional-audio equipment to accommodate the use of low-output ribbon and dynamic microphones. These microphone types are strictly passive electromechanical generators and do not require a power source. Phantom power earns its name from the fact that these microphone types "float" at 48V without harm. The electret capsules are available in various sizes and physical configurations. They include both omnidirectional and directional (cardioid) types. Directional capsules have a vent in the rear; you must mount them with free access to both the front and the back to obtain proper characteristics.

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Figure 1



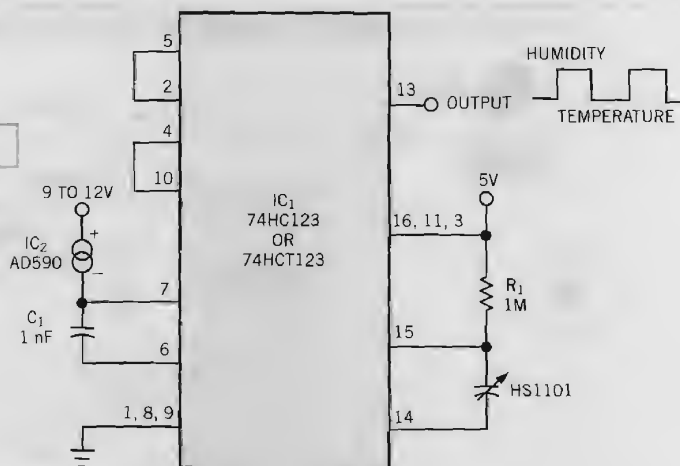
This microphone system derives its power from the receiving-end circuitry through the leads that carry the audio signal.

## Measure humidity and temperature on one TTL line

Shyam Tiwari, Sensors Technology Pvt Ltd, Gwalior, India

**B**Y COMBINING THE RESPONSES of an Analog Devices (www.analog.com) AD590 temperature sensor and a Humirel (www.humirel.com) HS1101 humidity sensor, you can generate a single TTL-level signal containing information from both sensors (Figure 1). This design uses a 74HC123 monostable multivibrator, IC<sub>1</sub>, to form a free-running oscillator. The AD590 current source (1  $\mu$ A/K), IC<sub>2</sub>, and a fixed 1-nF capacitor, C<sub>1</sub>, control the timing of the first monostable multivibrator in the 74HC123. Another monostable multivibrator uses a fixed 1-M $\Omega$  resistor along with the capacitive output of the HS1101 (172 pF at 0% relative humidity and 222 pF at 100% relative humidity) for its timing. Combining the two monostable multivibrators creates a free-running oscillator that produces a single-line signal from both sensors. The high- and low-level pulse widths carry the information related to the sensor signals. The AD590 circuit displays pulse-width reduction with rising temperature, because of its increased output current with higher temperatures. The HS1101 circuit displays

Figure 1



A monostable-multivibrator IC provides temperature and humidity information in one TTL signal.

increased pulse width with rises in humidity levels. The circuit in Figure 1 represents a simple method of transmitting signals from analog sensors by digital rather than analog means. The technique eliminates noise in signal transmission over long distances. You could add an op-

toisolator in the output path if you need, say, 1500V isolation.

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## Low-cost anemometer fights dust

Jim Christensen, Maxim Integrated Products, Sunnyvale, CA

**A**S HIGHER LEVELS of power dissipation underscore the need for cooling, more and more fans are finding their way into small electronic enclosures. The dust that fans pull into these enclosures can, however, cause major problems for high-reliability systems. By coating heat sinks and electrically charged components, the dust acts as a blanket that raises the effective thermal impedance between the components and the air. A simple way to combat this problem is to place a disposable filter on the

TABLE 1—FAN VOLTAGE VERSUS COOLING TIME

Fan voltage (V)	Cooling time (sec)
12	30
8	47
6	60
0 (no fan)	84

air intake. If you fail to replace the filter on a regular basis, however, it can become clogged and act as an air dam, a condition

that is worse than the original problem. Trying to sense a clogged filter by sensing the fan's rotation with tachometer signals is useless, because fan rotation is not directly related to airflow. You can detect poor filter maintenance by determining the actual airflow with a "hot-wire" anemometer, but most electronic anemometers are costly and bulky. As an alternative, you can create an SMBus/I<sup>2</sup>C anemometer using an I/O expander, a few inexpensive switches, and a low-cost remote-temperature sensor (Figure 1).

Use the SMBus I/O expander, IC<sub>4</sub>, to turn off MOSFETs Q<sub>1</sub> and Q<sub>2</sub> and to turn on the analog switches IC<sub>2</sub> and IC<sub>3</sub>. Measure the ambient air temperature with no preheating of Q<sub>3</sub>. Then, to apply current for heating Q<sub>3</sub>, turn off IC<sub>2</sub> and IC<sub>3</sub> and turn on Q<sub>1</sub> and Q<sub>2</sub>. Allow an approximate five-minute "soak" to reach temperature equilibrium. (The exact heating time necessary for equilibrium depends on the setup; you must determine it by experiment.) At equilibrium, remove power from Q<sub>3</sub> by turning off Q<sub>1</sub> and Q<sub>2</sub>, and turn on analog switches IC<sub>2</sub> and IC<sub>3</sub> to make temperature measurements. Airflow directly relates to the rate at which

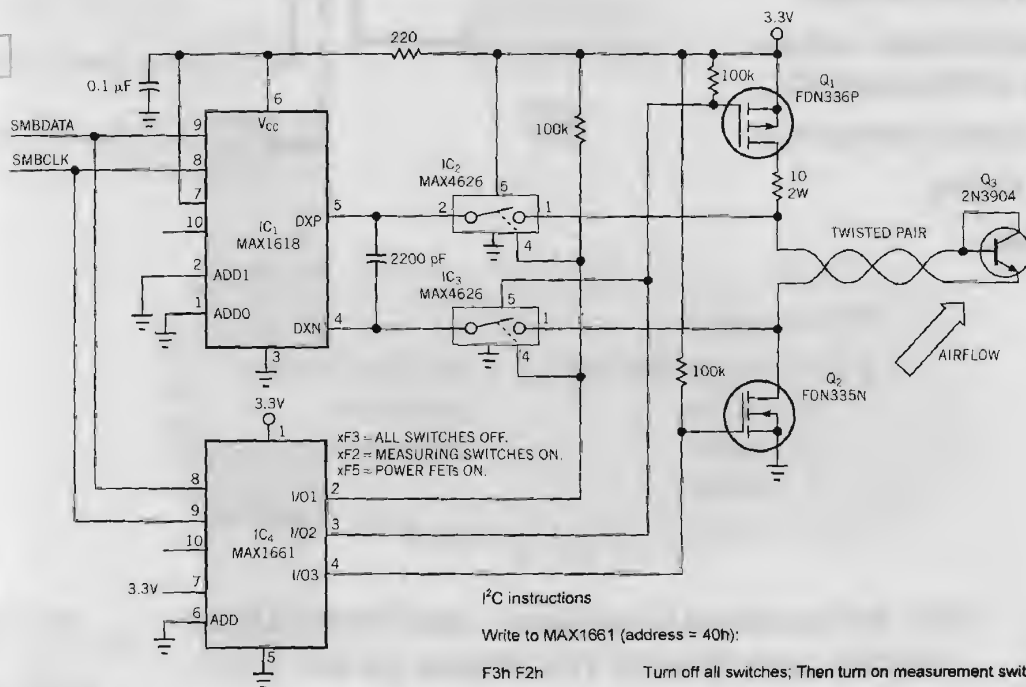
the temperature drops; you can determine it by noting the time required for the transistor to return to within 1° of its original temperature. The temperature sensor injects a small current into the base junction, so careful layout is important to keep noise off the DXP and DXN lines.

If you mount the remote transistor in an air channel, the use of twisted-pair wire allows distances to 12 ft. **Table 1** shows fan voltage (airflow) versus cooling time for a sensor placed approximately 12 in. away from a fan running at full speed (12V), medium speed (8V), low speed (6V), and zero speed. Soak

times as long as 30 minutes do not significantly alter the times. The circuit draws approximately 200 mA when Q<sub>3</sub> is heating. If this power dissipation poses a problem, you can lower the measurement frequency to hourly or even daily cycles, because changes in airflow occur slowly over time. You can also schedule the measurements during times of low system activity, when overall power use is low.

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Figure 1



#### I<sup>2</sup>C instructions

Write to MAX1661 (address = 40h):

F3h F2h Turn off all switches; Then turn on measurement switches

Write to MAX1618 (address = 30h):

09h 48h Write Configure; One shot mode  
0Fh Write one shot command  
W 01 R ??h Read ambient temperature

Write to MAX1661

F3h F5h Turn off all switches. Then turn on power FETs

Soak for 5 minutes

Write to MAX1661

F3h F2h Turn off all switches; Then turn on measurement switches

Write to MAX1618

0Fh Write one shot command  
W 01 R ??h Read temperature

Loop on last two statements and count the time it takes for the temperature to drop to the initial ambient temperature +1°

This anemometer measures airflow by heating Q<sub>3</sub> and then noting the time for Q<sub>3</sub> to return to its original temperature.